Drinking Water Treatment

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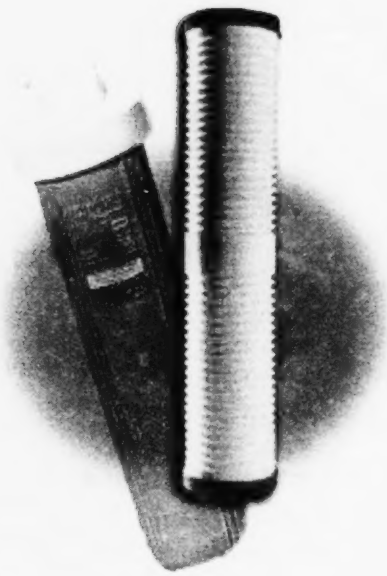

Drinking Water Treatment

A Guide for Owners of Private Communal Works and Other Small Water Supply Systems

December 2001

Ontario

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Public Works Management Inc., Morris Plains, New Jersey, specializes in reducing the operating costs of water and wastewater systems and providing expert advice related to alternative service delivery options.

NOTE TO READER

Drinking water treatment is a complex topic. This guide provides only a brief introduction to private communal water works and other small water supply systems and to appropriate treatment technology and its selection. It does not contain the level of detail or the extent of information needed to design a new water system or to correct problems at an existing system.

Each water system is unique. Users of this guide must determine which, if any, regulatory requirements are applicable to their water system and should always bear in mind that owners are ultimately responsible for producing safe drinking water. Read product literature completely, note any limitations, and follow the instructions carefully. Selection, installation and use of equipment and technologies, procedures and recommendations described herein should be done with the assistance of knowledgeable and competent experts. Every attempt has been made to assure the accuracy of statements made in this guide. The Ontario Ministry of the Environment and the authors do not assume any liability for errors or omissions.

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Attached to this guide is a list that may assist readers in locating water treatment service providers, accredited laboratories, and Internet information resources. Please note that the supplement is not exhaustive and there may be other service providers, laboratories, and resources in your local area.

OVERVIEW

Welcome to the first edition of the Ontario Ministry of the Environment's *Drinking Water Treatment – A Guide for Owners of Private Communal Works and Other Small Water Supply Systems.*

This guide contains three main sections:

MANAGING YOUR DRINKING WATER SYSTEM

The guide starts with a discussion about water quality, and about the types of contaminants that can be present in raw water that need to be removed in order to ensure the water is safe to drink. Possible causes of contamination are described along with measures that can be taken to protect your water source. Approaches to water system maintenance, including routine, corrective and preventive maintenance, are explained, and the guide contains suggestions for record keeping. Training opportunities are also identified.

WATER TREATMENT TECHNOLOGIES

Water supply systems are characterized according to the raw water source – that is, groundwater or surface water. The widely-accepted minimum treatment for groundwater systems is disinfection, and for surface water systems, it is filtration followed by disinfection. In this section of the guide, disinfection and filtration technologies are described, including applications and operational complexities of various options. Supplementary technologies that may be needed to address specific contaminants or conditions are also listed.

SELECTING THE APPROPRIATE TREATMENT TECHNOLOGY

Owners of small water systems have a number of alternative treatment configurations to choose from, namely centralized treatment, point-of-entry, and/or point-of-use. Some of the issues to consider when choosing among alternatives, such as cost, safety, operational ease, service life, and ancillary requirements (e.g. land), are highlighted. A list of "do's" and "don'ts" to keep in mind when purchasing water treatment equipment is provided, and the guide ends with some advice from water treatment professionals.

MANAGING YOUR DRINKING WATER SYSTEM

In general, the best defense against water quality problems is to (1) protect your water source, (2) have adequate treatment in place, and to (3) actively monitor and manage your water system.

In this section, you'll find useful tips and techniques for identifying water quality problems, sampling and testing your water, protecting your raw water source, and for keeping your water system up and running.

IDENTIFYING WATER QUALITY PROBLEMS

Whether water is safe to drink depends on the specific contaminants it contains, how much of each contaminant is present, and how these contaminants affect human health. How do you know the quality of your raw water source? Testing the water is the only way you can be sure.

The table below presents a simplified overview of the major contaminants you should test for.

Parameter	Comments
Microbiological Contaminants	• Microbiological contaminants in water - such as fecal coliforms (specifically *Escherischia coli* (*E.Coli*) bacteria) pose the greatest threat to human health. *E.Coli* is a more definitive test for fecal contamination. • The presence of fecal coliforms in water is an indication of contamination by human sewage or animal manure. • Septic systems, sewage treatment plants or runoff from livestock operations are all potential sources of microbiological contamination. • Bacteria are not usually found in groundwater unless the water is under the influence of surface water, or is contaminated by waste materials from storm runoff, via improperly constructed wells or from septic systems. • Special attention needs to be paid when shallow wells are constructed in limestone, fractured bedrock or gravel because these subsurface conditions allow for possible infiltration of surface water and rapid lateral movement of groundwater.

Parameter	Comments
Volatile Organics	• Volatile organic chemicals originating from solvents, degreasing agents and paint thinners, pose a threat to human health from ingestion (the primary route of exposure) and from inhalation or skin adsorption in showers, baths or while washing dishes as some of these chemicals (e.g. benzenes, vinyl chlorides, xylene) easily become gases. At low levels volatile organics can taint the water producing objectionable tastes and odours. • Disinfection by-products (e.g. trihalomethanes) are formed when disinfectants used in water treatment react with naturally occurring organic matter in the water. They are a concern because they are potentially cancer-causing.
Inorganics	• Inorganic contaminants include metals (e.g. arsenic, copper, lead, mercury), salts, dissolved gases and other chemicals that do not contain carbon. Most of these contaminants originate in the natural environment. For example, arsenic occurs naturally as an impurity in various minerals and in the ores of commercially-mined metals. • Nitrates, on the other hand, can be linked to the use of fertilizers, the presence of farm animal feedlots or leaking septic systems. Nitrates are prevalent in rural areas, and can cause the fatal 'blue baby' syndrome (methaemoglobinaemia). • Inorganic contaminants such as lead and copper can be introduced through the plumbing system. Lead can cause kidney and nerve damage, low birth weights, and mental impairment in children. Copper can cause gastrointestinal illness. Both copper and lead can leach into in-home drinking water when, for example, the pH of the water is low (acidic).
Pesticides and PCBs	• Pesticides and herbicides (e.g. diazinon, malathion) are synthetic chemicals - if ingested, these chemicals can cause liver and kidney damage, and can affect the central nervous system. • PCBs are found in electrical transformers and as fluid in vacuum pumps and compressors. Even though the use of PCBs has been banned in new products, residues from old products may still remain in the environment.

SPECIAL CONSIDERATIONS FOR MICROBIOLOGICAL SAMPLES

Sampling is a very important part of testing. Improper sampling technique may produce invalid results. Always follow the sampling instructions provided by the laboratory (see *Use an Accredited Laboratory* next page).

Special precautions should be taken with samples collected for microbiological analysis, which are perishable and easily contaminated. Instructions for collecting and transporting samples for microbiological analysis may differ from laboratory to laboratory but generally include the following:

- **Use a sterile, clear plastic, bacteriological sampling bottle** that contains sodium thiosulphate. These containers are provided by the laboratories contracted to do the analysis.
- **Do not rinse the container before collecting a water sample,** as this will remove the sodium thiosulphate. Samples can be easily contaminated and therefore must be collected in a sterile container while taking every precaution to ensure that fingers, hands, clothing, or any other unsterile objects do not touch the mouth of the bottle, the interior of the bottle, or the inner surface of the bottle cap.
- **The location from which samples are collected is important.** Remove any aerators, tap screens, hoses, filters, etc., from the location at which the sample is being collected. The sample should be taken quickly without exposing the open container to the air for long periods of time.
- **Clearly label the sample**, noting the date, time, and location from which the sample was taken
- To prevent significant changes, **water samples should be refrigerated immediately** after sampling. The sample should not be allowed to freeze, and it should be analyzed within 48 hours.

USE AN ACCREDITED LABORATORY

As the owner of a water supply, your best assurance of accurate test results is to use an accredited laboratory. Accreditation is: (1) a check of a laboratory's ability to show that it has a documented quality control system in place and the system is followed; (2) given to a laboratory for each specific test, for example, analysis of pesticides in drinking water - laboratories may be accredited for as few as one or two tests, or as many as 100; and (3) granted by the Standards Council of Canada upon the recommendation of the Canadian Association of Environmental Analytical Laboratories.

Accredited laboratories are contained in the list attached to this guide.

KEEP YOUR SOURCE WATER CLEAN

Once you have identified and confirmed the presence of contaminants in your raw water, you should explore the source. This can be easier said than done. Pinpointing contamination can be a challenge because some contaminants occur naturally in the environment. Consider the following (adapted from *A Guide to the National Drinking Water Standards and Private Water Systems* by the Virginia Water Resources Research Center, 1996):

- If your water is contaminated by fecal coliforms or nitrates, is it possible that runoff from an animal feedlot has polluted your water source? Is your well lined or cased? Is the well properly sealed, so that runoff is prevented from entering it? Could your septic system be malfunctioning? Are fertilizers applied to fields close to the well?

- If petroleum contamination is the problem, have you had a spill of gasoline from a gas tank, diesel from a fuel tank, or from an automotive repair area? Is heating oil leaking from a storage tank? Is the raw water source near a gas station or industry with underground or aboveground storage tanks? Have you spilled a petroleum product near the water source?

- If pesticides have been detected, is the source water near a large orchard, in an agricultural area, or next to a chemical manufacturer or distributor? Could runoff be entering an improperly sealed well?

- If the contaminant is an industrial chemical, check with your municipality about past land use practices in the area.

- If you have a well that is no longer used or has been abandoned, has it been properly sealed to prevent contamination? Has the abandoned well been used to dispose of wastes of any kind?

THINK PREVENTION

Preventive maintenance involves periodically servicing water system components in accordance with the manufacturer's recommendations and good industry practice. The purpose is to maintain equipment performance and service life. Examples of preventive maintenance include:

- ensuring filters and UV units are properly cleaned;
- applying oil and grease;
- replacing high-wear parts such as bulbs, belts, diaphragms, and tubing;
- calibrating chemical feed pumps; and,
- calibrating instruments, such as pH probes and flow meters.

Most preventive maintenance requirements are derived from the recommendations of the equipment suppliers combined with common sense. Common sense preventive maintenance might include checking to see that everything works, especially those items that are rarely used such as valves. Keep in mind that incorrect maintenance can also be harmful: using the incorrect replacement part or type of oil; or oiling or greasing items that should not be oiled or greased; or oiling/greasing items that come in contact with the drinking water.

MAKE IT ROUTINE

Your maintenance plan should include *routine* maintenance. This should include:

- checking the well cap for a tight seal,
- checking the fencing around the well and other wellhead protection measures,
- removing debris and overgrown weeds,
- cleaning up from any leaks,
- checking the chemical storage areas, including each pail, drum, or bag of chemical for corrosion, wear, or leaks.

For surface water sources, check the intake pipe area for debris and walk upstream to check for any signs of change or contamination. Look for algae or foaming of the surface water, which

are more prevalent during summer months and droughts (and, which may negatively impact the quality of your drinking water).

IF IT BREAKS, FIX IT

The overall maintenance plan should also include *corrective* maintenance. Corrective maintenance entails fixing equipment once it breaks. Making the most of corrective maintenance involves keeping up-to-date records of the literature for each piece of equipment, phone numbers of local service providers, sources of parts, and the like. It may also include keeping spare parts (i.e., pumps, filters, bulbs), supplies and tools on hand. If you conduct your own corrective maintenance, it is very important to use the correct materials that have been approved for drinking water use and comply with the recommended standard for such materials. This applies to paints, adhesives, pipes, tubing, tanks, etc. that may come in contact with the drinking water, regardless of whether it is before or after treatment. Also remember that if a breakdown makes it possible for untreated water to enter the system, the provision of water for human consumption must be discontinued until the problem is resolved. Distribution of untreated water to consumers is a dangerous practice.

ANTICIPATE PROBLEMS

Finally, the maintenance plan should attempt to incorporate *predictive* maintenance, which involves anticipating when components are likely to wear out or fail. The point of predictive maintenance is to continue using the component until the time just before it is expected to wear out. With predictive maintenance, you are trying to maximize service life without jeopardizing water quality (which would occur if you waited too long and the component failed).

By keeping records of corrective maintenance activities over a period of years, you can make an educated guess when equipment can be expected to fail next based on a historical analysis.

PUTTING YOUR PLAN TOGETHER

You can use a common desktop spreadsheet, a database management software program, or even a word processing program, to set up your maintenance plan.

The plan is best organized in two ways. First, list all the equipment, the required maintenance tasks and their frequency, and decide on a means of recording the completion of the maintenance (along with any observations made during maintenance) for each piece of equipment. Second,

develop a schedule of tasks that allows you to check off each item when completed. The schedule can also have an area where reminders and other "to-do" items can be recorded and readily observed – for example, "Order more chlorine solution tubing," or "Water pump is making noise – check every month instead of quarterly".

Many people use **3″ by 5″ cards** to construct their maintenance plan. The cards are used to record maintenance tasks for each piece of equipment or system component, and are placed in the month when the maintenance is scheduled to take place. The front of the card can be used to list what is to be done, for example, "Oil water pump model ABC located before the pressure tank monthly with five drops of oil". The back of the card can then be used to list the dates of completion, initials of the person doing the maintenance, and notes such as "Oil is leaking from seal," or "Pump is hotter to the touch than I remember."

Some people use a **logbook** to record maintenance and operating changes and rely on the 3″ by 5″ cards as maintenance reminders/instructions. In this case, it may be convenient to keep the logbook close to the water system, such as at the well house or in the surface water treatment system building. The advantage of this is that the logbook is located where the maintenance is being performed – this better ensures that maintenance will be recorded. Keep a pen tied to the book for convenience. Review logbook entries for trends. This is highly recommended if your system uses any chemicals.

Using the incorrect chemical is one of the easiest mistakes to make, especially if different brands of the same chemical are used, if different concentrations of the same chemical are on hand, or if more than one type of chemical from the same supplier is used and they have a similar appearance.

Keep your records in a dry location that is easily accessible. Well houses and pump rooms are often wet and damp, and may not be suitable storage locations (possibly with the exception would be the aforementioned logbook). Keep spare parts and other maintenance materials in a separate, dedicated area.

Keeping up-to-date equipment literature is also important. Components may arrive without the installation or warranty information, or the installer may open the box elsewhere and discard the literature with the box (this is common, since the installer has long ago memorized what he or she needs to know from the literature). Consider holding final payment for installation of a water system, well, pump, or other major component until the service provider has given you the correct and complete literature for all installed equipment – including recommended and/or

required maintenance tasks, operating instructions, parts lists, sources of parts, service providers, chemical dosage calculations, and warranty. In addition, make sure the service provider fills out any warranty, and that you are listed as the person protected.

TAKE A TRAINING COURSE

The Ontario Environmental Training Consortium (OETC) can provide a list of correspondence courses and classroom training for operators of small water systems (e.g., rural subdivisions, mobile home parks, various tourism-related facilities). These courses explain water system components and their operation (e.g., wells/intakes, treatment, pumping, storage, distribution); describe the various methods of disinfection, particularly chlorination; explain why and when filtration is needed; and help build competency in monitoring and sampling. Visit the OETC website at www.oetc.on.ca for more details.

WATER TREATMENT TECHNOLOGIES

Treatment to produce safe drinking water depends on the raw water source that is used. Some natural purification occurs in surface waters as a result of dilution, storage, sunlight and associated physical and biological processes. With groundwater, natural purification may occur by infiltration of rainfall through soil and percolation through underlying porous materials such as sand, gravel and bedrock. Groundwater should be considered first by small water systems as a potential source of drinking water. In either case, effective treatment should be provided to ensure safety and consistency in the quality of drinking water.

- The widely-accepted minimum treatment for a **groundwater** source is *disinfection*.

- The widely-accepted minimum treatment for a **surface water** source is *filtration followed by disinfection*. This minimum level should also be applied to a groundwater source that is under the direct influence of surface water.

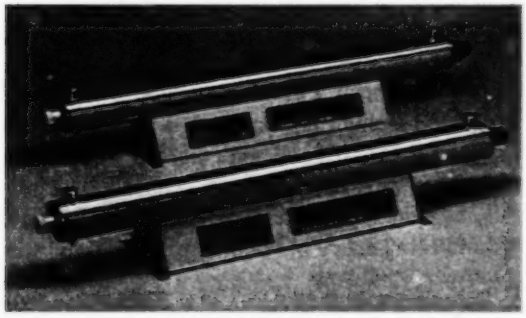
This section of the guide presents information about disinfection and filtration, including methods and applications. Supplementary treatment technologies that can be used to address particular water quality problems are also listed.

DISINFECTION

Disinfection of water to eliminate disease-causing organisms is the most important step in the drinking water treatment process. Disinfection is a chemical (or photochemical) process that destroys or impairs an organism's cell structure, metabolism or ability to grow.

Certain disinfectants can produce potentially harmful disinfection by-products when the disinfectant reacts with natural organic matter in the water. These contaminants are costly to remove from drinking water once they are formed – it is better to remove the natural organic matter prior to disinfection.

High flow ultraviolet disinfection unit



Common methods of disinfection include

A. CHLORINATION;
B. CHLORINE DIOXIDE;
C. CHLORAMINATION;
D. ULTRAVIOLET IRRADIATION;
E. OZONATION; AND
F. DISTILLATION.

Summary information about disinfection technologies is presented below. The information is not exhaustive. Readers should always follow manufacturer's recommendations and/or seek qualified advice.

A. CHLORINATION

Chlorine is the major disinfectant used to treat drinking water. It is a powerful oxidant that is highly corrosive. Properly administered, chlorine is effective against bacteria, viruses, and *Giardia* (but not *Cryptosporidium*) and a residual level of chlorine can be maintained in the distribution system to prevent re-growth of these microorganisms. It can be a relatively low cost option. Common forms are sodium hypochlorite and chlorine gas. Chlorination does have disadvantages - it can cause iron to precipitate as a solid (which must be removed via filtration). Furthermore, disinfection by-products may be formed when chlorine reacts with natural organic compounds in water.

Sodium hypochlorite

- Available as a liquid (bleach) in a range of concentrations.
- Easier to handle than chlorine gas or calcium hypochlorite.
- Can present a fire hazard, is very corrosive, and must be kept away from equipment that can be damaged by corrosion.
- As the sodium hypochlorite ages, its strength decreases, so it may be necessary to increase dosage to achieve the same level of chlorine residual.

Chlorine gas

- Very powerful disinfectant; can be lethal if handled improperly.
- Generally not used at smaller water systems.

B. CHLORINE DIOXIDE

Chlorine dioxide (ClO_2) is a powerful oxidant that is more difficult to handle than other forms of chlorine. It must be generated on-site and requires trained staff to manage its use, and is so reactive that it may not provide a residual disinfectant in the distribution system. Chlorine dioxide is generally not used at smaller water systems.

C. CHLORAMINATION

Chloramine is created by combining chlorine with ammonia. It is a weak, but persistent, disinfectant that is much less effective against viruses and cysts (such as giardia) than other forms of chlorine. Chloramination requires operators that possess an intermediate level of skill. This disinfection technology is often used as a secondary disinfectant to prevent bacterial regrowth in distribution systems. Chloramination is generally not used at smaller water systems.

D. ULTRAVIOLET IRRADIATION (UV)

Ultraviolet (UV) radiation is generated by a special lamp. It effectively destroys bacteria, viruses and cysts by penetrating cell walls and rendering the organisms unable to reproduce. UV light assemblies are self-contained – water flows around the UV lights, which are housed in protective sleeves.

- Effectiveness is influenced by light intensity and contact time (which is relatively short).
- Easy to operate and generally requires less maintenance than chlorine systems.
- Microbiological contaminants are killed without generating disinfection by-products (or other toxic substances).
- Does not leave any disinfectant residual in the water.
- Presence of iron, hydrogen sulfide, suspended solids, manganese, turbidity, colour, soluble organic matter and/or hardness inhibits effectiveness.

E. OZONATION

Ozone (O_3) is a pale blue gas with a distinct odour. It is generated on-site by passing dried air or oxygen gas (stored in cylinders) through an ozone generator, and is bubbled into the water.

- A powerful disinfectant.
- Because of its unstable nature, it is necessary to generate ozone on-site.
- Costs are relatively high compared to other disinfection methods.
- Operation and maintenance are relatively complex.
- Requires shorter contact time and lower dosages than chlorine.
- Can react with bromides in the water to create disinfection by-products.
- Does not leave an adequate disinfectant residual in water.

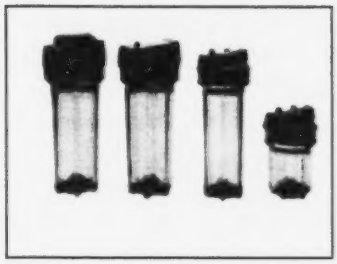
F. DISTILLATION

Distillation involves boiling water to steam, which is condensed back into water and collected in a purified form.

- Distillation units have small capacities, use considerable energy to process water, and are most often limited to point-of-use systems.
- Commonly used for removing nitrate, bacteria, sodium, hardness, dissolved solids, most non-volatile organic contaminants, heavy metals and radionuclides from water.
- Mechanically simple and relatively easy to maintain; basic operator skill required.
- May actually increase the concentration of some organic contaminants, certain pesticides, and volatile solvents.
- Bacteria may re-grow on the cooling coils when the distillation system is out-of-service or not in use.

FILTRATION

Filtration is used to physically remove suspended particles (including microbiological contaminants) from the water. If your raw water comes from a surface water source, or your groundwater is under the direct influence of surface water, you should include filtration as part of your drinking water treatment system. Often, chemicals known as coagulants must be added to the water prior to filtration to improve removal of these particles. These chemicals cause the particles in the water to clump together, increasing the removal effectiveness of the filter.



Filter Cartridges

Filtration technologies include:

A. MECHANICAL FILTRATION

This type of filtration relies on sand, spun cellulose or other media to trap contaminants. It includes cartridge filters, bag filters, diatomaceous earth filters and granular media filters.

B. MEMBRANE FILTRATION

This is a pressure-driven process whereby water is pushed through a permeable membrane, leaving particles behind. Examples are microfiltration and ultrafiltration. Reverse osmosis is another membrane process that operates at high pressure using a semi-permeable membrane.

Summary information about filtration technologies is presented below. The information is not exhaustive. Readers should always follow manufacturer's recommendations and/or seek qualified advice.

A. MECHANICAL FILTRATION

Cartridge Filters

- Typically contain spun cellulose as the filter media.
- Suitable for removing bacteria, protozoa and other particles.
- Work best with water that is low in turbidity and microbiological contaminants.
- Relatively easy to operate and maintain; basic operator skill required.
- A disinfectant may be needed to prevent microbial growth on the cartridge surface.

Bag filtration

- Based on physical screening process.
- If the pore size of the bag filter is small enough, protozoa will be removed.
- Raw water should be of relatively high quality otherwise pre-treatment using granular media filter might be required.
- Basic operator skill required.

Diatomaceous earth filtration

- Relies on a thin layer of diatomaceous earth that is placed on the filter element.
- Most suitable for water that is low in microbiological contaminants and turbidity.
- Effective in removing protozoan cysts; chemical coagulants are required for effective virus removal.
- Filters need to be backwashed - the backwash water contains diatomaceous earth, which can present disposal problems.
- Intermediate operator skill required.
- Typically used when there is limited initial capital, and for emergency or standby capacity to service large seasonal increases in demand.

Conventional (rapid sand) filtration

- Consists of a bed of granular material (e.g. sand, anthracite) supported by a layer of gravel and an underdrain system.
- Water passes downward through filter media by a combination of positive head and suction from the bottom.
- Contaminant removal process is complex, and occurs throughout filter bed.
- Filter bed must be backwashed (cleaned) to maintain on-going effectiveness.
- Intermediate operator skill required.

Slow sand filtration

- Consists of a bed of sand supported by a layer of gravel and an underdrain system.
- Contaminant removal occurs on the surface of the filter bed.
- Operates at very slow flowrate (e.g. $1/100^{th}$ the rate of conventional filters).
- Requires large filters and therefore more space due to low flowrate.
- Maintenance consists of periodic scraping and disposal of the surface layer to ensure adequate on-going performance.

- Low cost, simple to operate, and reliable but must be operated year round; basic operator skill required.
- Does not require the use of chemicals to assist filtration.

B. MEMBRANE FILTRATION

Membrane filtration provides a physical barrier (the membrane) that can remove most particles. The membrane has microscopic openings that allow water molecules, but not larger compounds, to pass through. Generally, as the pore size decreases, more substances are removed but capital and operating costs increase. Replacement of the membranes can be a significant maintenance cost, flow rates can significantly decrease as the water temperature decreases, and there can be a significant backwash flow (i.e. wastage of water) relative to the total flow as compared to other filtration techniques. Membrane filters typically require operators at the intermediate skill level (except for reverse osmosis).

Microfiltration

- Operates under the lowest pressures and has the largest pore sizes.
- Primary application is particulate removal, including bacteria and protozoa.
- Removes bacteria and protozoa.

Ultrafiltration

- Pore size is smaller and operation is under relatively higher pressures than with microfiltration.
- Used for removal of particulate, but will usually not remove hardness or disinfection by-product precursors.
- Removes bacteria, protozoa and some viruses.

Nanofiltration

- Relies on the smallest pore sizes and operates under the highest pressures.
- Removes particulates, ions contributing to hardness (i.e., calcium and magnesium), colour, and most disinfection by-product precursors.
- Removes bacteria, protozoa and all viruses.

Reverse Osmosis

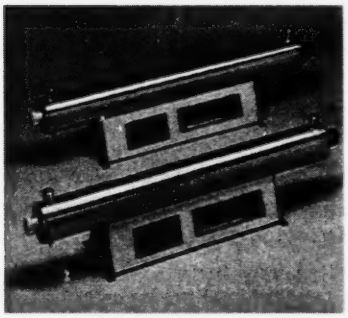
- Typically used to reduce the levels of total dissolved solids and suspended matter, including nitrate, sulfate and sodium.
- Removal effectiveness depends on the contaminant and its concentration, operating pressure and membrane characteristics (e.g. some RO membranes have an electrical charge that helps in rejecting some chemicals at the membrane surface).
- Generates a large volume of wastewater.

TREATING SPECIFIC CONTAMINANTS

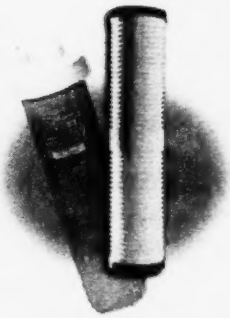
Minimum treatment should be employed in any water treatment system. These processes treat the majority of contaminants that can affect human health. However, you may have a specific contaminant or condition that requires special attention. The table below lists some common problems and associated treatment strategies. The information is for illustrative purposes and is not exhaustive. Readers should always follow manufacturer's recommendations and/or seek qualified advice.

PROBLEM	TREATMENT
Taste and Odour	Activated carbon
Corrosion	pH adjustment using calcium carbonate, sodium carbonate, lime, or sodium hydroxide
Hardness	ion exchange (water softening)
Iron and Manganese	ion exchange; greensand filtration; chemical oxidation plus filtration

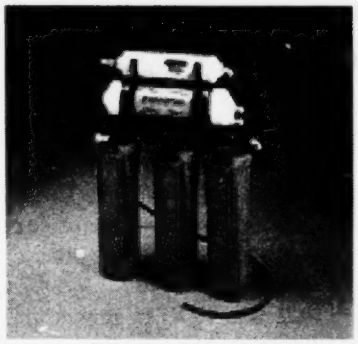
SELECTING THE APPROPRIATE TREATMENT TECHNOLOGY



UV Disinfection



Mechanical Filtration



Reverse Osmosis System

If one or more water quality problem exists, you should try to identify and eliminate the source of the contaminant. Once you decide to treat the water, bear in mind that the widely accepted minimum treatment for a **groundwater** source is **disinfection**. The widely accepted minimum treatment for a **surface water** source is **filtration followed by disinfection**; this minimum level also applies to a groundwater source that is under the direct influence of surface water. Any other technologies should be supplementary to the minimum treatment required for your raw water source.

Choosing a water treatment technology can be confusing, because many times you cannot treat one problem without treating another first, and sometimes the treatment itself can cause problems. Seek the advice of qualified experts. Read product literature completely, note any limitations and exceptions, and follow installation, operation, and maintenance instructions carefully.

Once you have determined the water quality problem(s) and narrowed your treatment options, it's time to look at the system configuration alternatives, costs (including capital, on-going operation, and maintenance), and service needs of the various options

SYSTEM CONFIGURATION ALTERNATIVES

Owners of private communal works and other small water supply systems can consider three system configuration options:

1. **Centralized Treatment** - water is treated at a single (centralized) location before it enters the distribution system;
2. **Point of Entry (POE)** - water is treated at the place where it enters a household or other building; and,
3. **Point of Use (POU)** - treat only the water to be consumed at a particular tap.

Centralized treatment is generally preferred over point-of-use and point-of-entry because monitoring and maintenance can be centrally managed, which is the most reliable way to ensure safe water. However, other considerations, such as cost, may come into play.

POE and POU treatment units generally rely on the same fundamental concepts used in the centralized treatment equipment - the main differences are that these units are smaller and the flows being treated are lower.

When POU units are used, they must be applied at all fixtures where water for drinking is required. For instance, if a unit is placed under the kitchen sink, only that water will be treated. If no other units were installed, then people brushing their teeth in the bathroom or showering would still be exposed to contaminants in the raw water. If these contaminants are a concern, then POE or centralized treatment is more appropriate. However, POE units may have special requirements that can increase costs. For example, some POE filters need to be backwashed or regenerated in order to maintain effectiveness. Also, if the backwash has special disposal requirements, you may incur higher costs.

WHAT TO CONSIDER WHEN CHOOSING EQUIPMENT

As an owner/operator of a private communal waterworks or other small water supply system, your primary concern when choosing equipment is that the technologies, equipment, and/or system that you choose will treat your raw water to produce consistently safe drinking water.

Note that drinking water equipment is generally sized in imperial units, with U.S. gallons the standard volumetric measure. To convert from Alitres@ to U.S. gallons, multiply the number of litres by 0.264. For example, if you need to treat 20,000 litres per day, then look for equipment that will treat 20,000 x 0.264 = 5,280 U.S. gallons per day.

When comparing different technologies and systems, consider the following:

- **capital costs** (purchase and installation);
- **operating costs** including chemicals, electricity, periodic replacement of media or membranes, need for certified operator etc.;
- **safety**, the risk of operation and maintenance (i.e. hazardous chemicals);
- **space** requirements;
- **reliability**; in terms of risk of a treatment component failure, effects of large variations in flow rates and raw water quality, and the effect of turning the system off for periods of time;
- **ease of operation;**
- **testing** requirements and associated costs;
- **service life**, annual maintenance requirements, and warranties.

EQUIPMENT COSTS

Below are sample costs for various treatment methods. The costs shown in the table are estimated capital costs, and do not include the cost of on-going operations and maintenance.

TREATMENT METHOD	PRICE RANGE	COMMENTS
DISINFECTION		
Chlorination System	$10,000 - $15,000 Centralized	Cost shown is for complete system (includes pump, retention tank and piping) sized to serve a lodge with five cottages drawing well water; includes installation.
Ultraviolet Irradiation	$1,000 - $5,000 Centralized (< 40gpm) $600 - $900 POE	Unit should have a monitor to alert you when lamp fails or intensity is too low (not yet practical).
Ozonation	$1,500 - $1,800 POE	Ozone generated on-site.
Distillation	$100 - $800 POU	Electricity costs and maintenance requirements may be high.
FILTRATION		
Filter (mechanical)	$400 - $1,500 POE	May be simple screen, multi-media or ceramic cartridge containing layered media.
Reverse Osmosis	$90 - $1,500 POU $600 - $2,500 POE	Generates a significant amount of wastewater; needs minimum household water pressure.
SUPPLEMENTARY		
Water Softener (ion exchange)	$1,000 - $1,500 POE	Resin is recharged with sodium.
Activated Carbon	$10 - $80 for POU $150 - $800 for POE	POU unit for tastes and odours only; carbon cartridge needs replacement.
Iron and Manganese Removal	$400 - $800 POE	Greensand filter; resin must be recharged with potassium permanganate.

- *The unit costs presented in the table are for illustrative purposes only. Your costs will be a function of the quality of your raw water. Excludes installation, unless otherwise noted.*

When comparing equipment, capital cost is not the only cost that should be considered. There will be on-going operating costs, principally electricity and chemicals, as well as labour and space/storage requirements. There may be periodic costs that arise only every several years, such as membrane replacement or replacement of ion exchange resin. There may be a cost for warranties or for extended warranties. Each of these costs should be taken into consideration when comparing total costs.

Also, compare the costs of a centralized system versus point-of-entry/point-of-use (POE/POU) systems. For certain conditions, it may be less costly to install individual units than a centralized system. For a centralized treatment system, it may be necessary to install one or more supplementary pumps such as a water and/or chemical feed pump (between $500 and $700);

retention or storage tanks (from $500 - $1,000 per 120 U.S. gallon tank); ancillary devices such as flow meters (approximately $100); and piping. However, testing could be more extensive for POE/POU systems because the treated water from each unit needs to be tested to give assurance of effective operation.

WHEN YOU'RE READY TO BUY

Consider the following list of questions when you are ready to contact equipment suppliers and installers:

Company History and Customer Satisfaction

How long has the company been in business? Have any complaints been filed against the company? Check with the Better Business Bureau or the Ontario Ministry of Consumer and Commercial Relations. Ask for references from past customers, especially those in your area treating the same water source, and contact them to find out how satisfied they were with the product and the service.

Your Water Quality

After you have talked to the dealer, ask about possible water quality problems. What tests will be performed? Who will perform them? If an on-site test was performed on your water, what did the results show? Be aware that on-site test kits can really only determine basic water quality (e.g., pH, hardness, turbidity, iron). Many contaminants associated with a serious health hazard require sophisticated procedures and equipment that are only available at an accredited laboratory.

Equipment Performance and Features

Is the equipment easy to maintain or complex? Will the company retest the water after several months to ensure that the equipment is working properly? Is there an indicator light or alarm to let you know when the equipment is malfunctioning? Find out who is responsible – the manufacturer or the supplier – in the event of equipment malfunction. Ask for a written guarantee that the equipment will perform as promised or the problem will be fixed at no charge or your money refunded. In case of an emergency, does the company offer 24-hour service and support?

Capital and Operating Costs

What is the total cost of operations and maintenance? Does the supplier offer service contracts to maintain the equipment? In addition to the purchase price, is there a cost for installation? What other costs are associated with using the equipment? Electricity? Additional space and heating requirements for storage tanks, pumps, chemicals? Replacement cartridges/bulbs? Filter membranes?

Operation, Maintenance, And Service Life

If you have a septic tank, can it accommodate the by-products of water treatment? Does the used activated carbon filter and contaminants collected in it have to be disposed of as hazardous waste? Can you perform maintenance or must a water treatment professional be involved? How frequently will maintenance be required? Under your operating conditions, how long can you expect equipment to last? What is covered in the warranty and for how long? What measures must be taken to avoid freezing and other cold weather problems?

A Word About Approval Ratings

The Ontario Ministry of the Environment is responsible for approving entire water systems on a site-specific basis, however, it does not approve technologies or drinking water equipment. There are, however, third party organizations that test the particular equipment under specific operating conditions. These organizations include the Canadian Water Quality Association (www.cwqa.com), the National Sanitation Foundation (www.nsf.org), and the Standards Council of Canada (www.scc.ca). Testing by these organizations is often done at the request of equipment manufacturers. As a result, not all equipment will necessarily have been tested by these organizations.

BE INFORMED

The best defense for protecting your health and those of the people who rely on your system for drinking water is common sense. If you choose to ignore the safety and security of your water supply, it may cost you money, peace of mind, and expose you and others to unnecessary health risks.

Because people are naturally concerned about health, and because relevant information about water and water treatment equipment is often technical, there is considerable opportunity to become confused and misinformed.

Generally, dealers and suppliers tend to provide quality service and products. However, buyers should exercise caution with respect to claims made regarding the recognition or approval of water treatment technology. The Ministry of the Environment approves water works on a site-specific basis, but does not approve specific water treatment technologies or pieces of equipment.

Confusion can also be created by the terms used to describe the effectiveness or performance of equipment. For example, a claim that a technology will "remove" a contaminant may not mean 100 percent removal. Also, a claim that a technology will produce "pure" water may not be accompanied by a definition of purity. A claim may also be made for a technology to remove 99 percent of a contaminant, but although this sounds good, it may not be sufficient depending on the level of the contaminant in the water being treated and the drinking water standard that may need to be achieved.

Before you sign any sales agreement:

- Consider changing your raw water source (e.g., by drilling a new well) as an alternative to treating contaminated water.
- If treatment is required, ensure that the equipment is appropriate for treating the contaminants in your raw water.
- Cost is only one consideration. Purchase price does not necessarily correlate with equipment performance.
- Take your time. Be sure to thoroughly investigate equipment and manufacturers' claims before making a purchase.
- Ask for guarantees in writing. Understand what is included and what other on-going costs you will incur.

ADVICE FROM THE PROS

In developing this guide, we talked to a number of water treatment service suppliers. We asked them to provide tips and techniques for purchasing, maintaining, and managing your water treatment system. Here's what they said:

1. **Advice is free - use it.** Manufacturers may produce different brands, for different distributors, with different specifications, at different price points. Visit a showroom to view and compare products, and speak to sales representatives. A reputable dealer should be interested in helping you. Talk to several dealers in your area. Sorting through the wide range of technologies and treatment applications can be a daunting task. Are you getting better service? Better product? Or better price? Since you want your water treatment equipment to effectively remove contaminants over a long period of time, it is important to find a service provider you can trust.

2. **Make sure you compare "apples to apples".** When comparing different *brands* of the same technology, or comparing costs of different *types* of technology, make sure the comparisons are appropriate. One brand may have a high initial capital cost but lower operating costs. Another brand may have a ten-year warranty compared to a 25-year warranty. Yet, another brand may use the same technology but cost more because of a compact design that requires less space.

3. **There is no "one size fits all" solution.** Every situation is different. Putting the water treatment system together involves integrating individual equipment components. The components will depend primarily on existing raw water quality, flow rate, pipe diameter, and considerations such as space, storage, operator skill requirements, personal preference and cost. Most filters, reverse osmosis units, UV units, and chlorination systems are available for almost any application and/or flow rate from residential through light commercial, to large industrial and municipal applications. Often, it is simply a matter of proper sizing.

4. **You'll never know unless you test.** In the absence of water testing, some people may opt to purchase water treatment equipment that disinfects and filters as many contaminants as practical. While this may appear to save money, it is a good idea to test water quality *before* equipment is installed. This way you have a reference point against

which to monitor equipment performance. Periodic water testing will tell you if the equipment is operating properly and is being maintained correctly.

5. **Plan for the unexpected.** Consider a back-up, in case something goes wrong. Rather than purchasing, for example, one 40 U.S. gpm UV lamp system, consider purchasing and installing two-24 U.S. gpm units in tandem, or integrate a spare chlorinator pump into your system. In this way, if one component fails, you can rely on the back-up to continue producing drinking water. Furthermore, you may find the price of two smaller units is more economical than one large unit.

IT'S UP TO YOU

If you've read this guide from beginning to end, you should have a better understanding of the treatment technologies available. However, reading without action will do little to ensure your water supply is safe to drink. It's time to act.

Whether you are an owner of a private communal waterworks, or another type of small water supply system, you need to make sure you have done your best to facilitate the provision of safe drinking water. You are probably doing that right now. If you are not, this guide provides the tips and techniques to get your water flowing.

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